# DEMONSTRATION OF AN INTEGRATED APPROACH TO MERCURY CONTROL AT LEE STATION

Quarterly Report No. 1

June 27, 2005 – September 26, 2005

Prepared by:

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DOE Contract No. DE-FC26-05NT42310

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Submitted by:

GE Energy

Energy and Environmental Research Corporation (GE EER)

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Disclaimer

## Abstract

In this project General Electric Energy and Environmental Research Corporation (GE EER) conducts a field evaluation of a novel multi-pollutant control technology for coal-fired power plants that can reduce emissions of mercury (Hg), oxides of nitrogen ($NO_x$), and carbon monoxide (CO) while simultaneously improving plant efficiency and reliability. The technology evaluation takes place in Lee Station unit 3 located in Goldsboro, NC and operated by Progress Energy. Unit 3 burns a low-sulfur Eastern bituminous coal and is a 250 MW opposed-wall fired unit equipped with an ESP. Unit 3 is equipped with a Separated Overfire Air (SOFA) system for $NO_x$ control. The program comprises field and pilot-scale tests, engineering studies and consists of eight tasks. Activities during the reporting period (June 27 – September 26, 2005) included signing a host site agreement between GE EER and Progress Energy, conducting baseline mercury measurements in unit 3, placing an order for adjustable riffle boxes with Foster Wheeler, delivery of the boxes to Lee station, and installation of the adjustable riffle boxes on mills A and B.

## Table of Contents



## List of Figures



## List of Tables

## Executive Summary

In this project General Electric Energy and Environmental Research Corporation (GE EER) conducts a field evaluation of a novel multi-pollutant control technology for coal-fired power plants that can reduce emissions of mercury (Hg), oxides of nitrogen ($NO_x$), and carbon monoxide (CO) while simultaneously improving plant efficiency and reliability. The technology evaluation takes place in Lee Station unit 3 located in Goldsboro, NC and operated by Progress Energy. Unit 3 burns a low-sulfur Eastern bituminous coal and is a 250 MW opposed-wall fired unit equipped with an ESP. Unit 3 is equipped with a Separated Overfire Air (SOFA) system for $NO_x$ control.

The technical goal of the project is to evaluate the technology's ability to achieve 70% Hg reduction below baseline emissions. GE EER's strategy to achieve the 70% incremental improvement in Hg removal in unit 3 is (1) to enhance "naturally" occurring fly ash Hg capture by optimizing the combustion process and using duct humidification to reduce flue gas temperatures at the ESP inlet, and (2) to use injection of small amounts of activated carbon in front of the ESP as a Hg removal polishing step. Other potential benefits of combustion optimization will include reduced $NO_x$ emissions, improved boiler performance, and increased heat efficiency.

The program comprises field and pilot-scale tests, engineering studies and consists of eight tasks. Activities during reporting period (June 27 – September 26, 2005) included signing a host site agreement between GE EER and Progress Energy, conducting baseline mercury measurements in unit 3, placing an order for adjustable riffle boxes with Foster Wheeler, delivery of the boxes to Lee station, and installation of the adjustable riffle boxes on mills A and B.

## 1.0 Introduction

The objective of this program is to conduct a field evaluation of a novel multi-pollutant control technology for coal-fired power plants that can reduce emissions of mercury (Hg), oxides of nitrogen ($NO_x$), and carbon monoxide (CO) while simultaneously improving plant efficiency and reliability. The technology evaluation takes place in Lee Station unit 3 located in Goldsboro, NC and operated by Progress Energy. Unit 3 burns a low-sulfur Eastern bituminous coal and is a 250 MW opposed-wall fired unit equipped with an ESP. Unit 3 is equipped with a Separated Overfire Air (SOFA) system for $NO_x$ control. Depending on combustion conditions and mills settings, the LOI generally varies from 12 to 21%. Most fly ash from Unit 3 is currently landfilled. The Unit 3 ESP has specific collection area (SCA) of 249 $ft^2$/kacfm and operates at temperatures around 280$^o$F. The ESP is equipped with an $SO_3$ conditioning system.

The technical goal of the project is to evaluate the technology's ability to achieve 70% Hg reduction below baseline emissions of 2.9 lb/TBtu. GE EER's strategy to achieve the 70% incremental improvement in Hg removal in unit 3 is (1) to enhance "naturally" occurring fly ash Hg capture by optimizing the combustion process and using duct humidification to reduce flue gas temperatures at the ESP inlet, and (2) to use injection of small amounts of activated carbon (AC) in front of the ESP as a Hg removal polishing step. Combustion optimization will be achieved through (1) balancing coal flow through individual burners using adjustable riffle boxes and (2) modifications to boiler burner and air settings and optimization of existing SOFA systems. CO monitors will be temporarily installed for the program duration to assist in fine tuning of the combustion process, in the expectation that CO levels will be reduced as OFA optimization for mercury control is brought about. Operation of the OFA system will be then optimized using data provided by the CO monitors and by controlling coal flows using adjustable riffle boxes and air flows to individual burners to maximize Hg removal and oxidation, along with $NO_x$ control. Mercury oxidation and absorption on the fly ash will be improved (1) by increased reactivity of fly ash towards Hg as a result of combustion optimization and (2) by lowering ESP temperature below 280$^o$F by utilizing humidification system. That system will also improve fly ash resistively which will allow for some flexibility in operation of the $SO_3$ conditioning system. Since acidic gases like $SO_3$ can potentially improve Hg oxidation, effect of $SO_3$ conditioning on Hg oxidation will be studied and $SO_3$ injection rate will be optimized to maximize Hg oxidation.

Other potential benefits of combustion optimization will include reduced $NO_x$ emissions, improved boiler performance, and increased heat efficiency.

The program comprises field and pilot-scale tests, engineering studies and consists of eight tasks. Activities during current reporting period (June 27 – September 26, 2005) included signing a Host Site Agreement between GE EER and Progress Energy, conducting baseline mercury measurements in unit 3, placing an order for adjustable riffle boxes with Foster Wheeler, delivery of the boxes to Lee station, and installation of the adjustable riffle boxes on mills A and B.

## 2.0 Program Management Activities

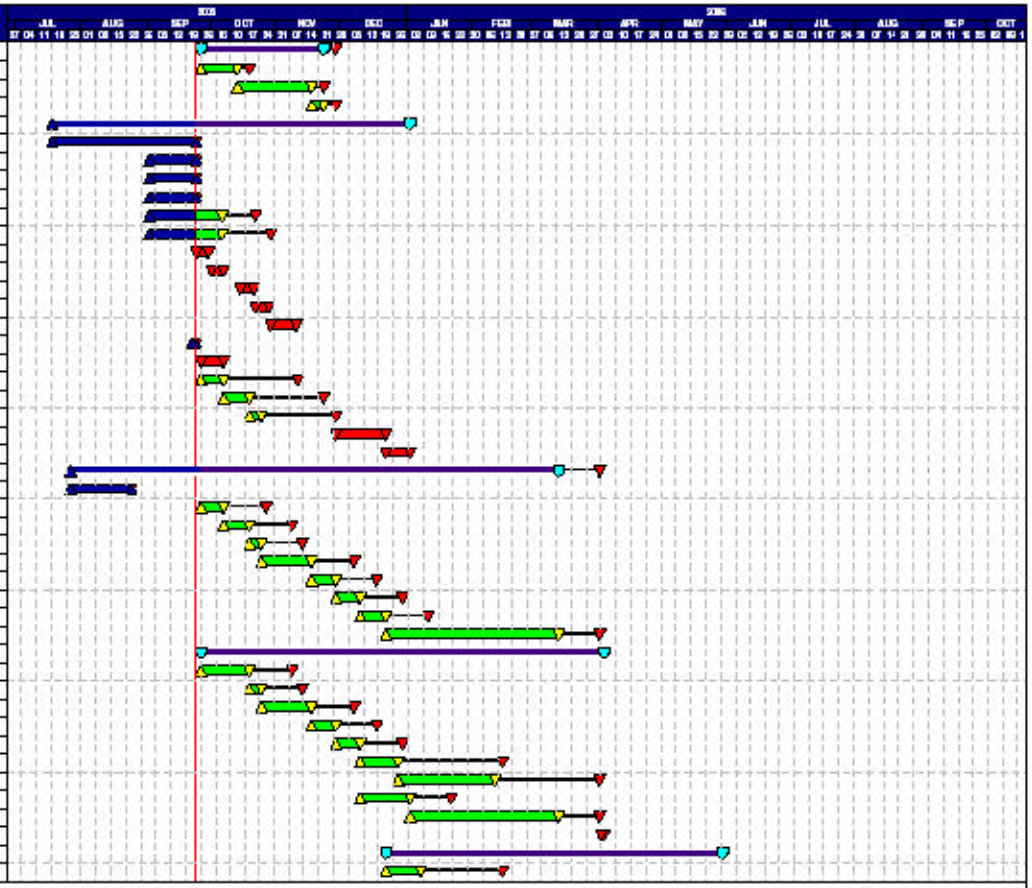
On June 16 the GE EER project management team met with U.S. DOE NETL personnel to discuss project objectives, tasks, and schedule. Project reporting requirements and the draft Host Site agreement between GE EER and Progress Energy were reviewed. Program technical approach was also presented and discussed.

The Project Initiation meeting at DOE NETL followed by three meetings between GE EER and Progress Energy to finalize the Host Site Agreement and to define task schedule and requirements for project support by Progress Energy. The Host Site Agreement was finalized and signed on June 22 and is presented in Appendix A.

Table 1 shows the overall program schedule and the schedule for each sub-task. Program activities are scheduled in such a way that all combustion optimization activities are completed by January 2006, duct humidification and sorbent injection systems are installed during spring 2006 outage, and Hg testing is conducted during summer 2006. This overall program schedule was selected because Lee Station unit 3 is a peak load unit operating a significant portion of the time at reduced load. Because of high demand for electricity during summer it usually operates at full load from June to August.

Table 1. Program schedule.

| Activity ID | Description | Early Start | Early Finish | Late Finish | Orig Dur | Act Dur | Rem Dur | Actual Start | Actual Finish |
|---|---|---|---|---|---|---|---|---|---|
| A001 | COAL CHAR. AND PILOT OPTIM. | 09-26-05 | 11-22-05 | 11-28-05 | 50* | 0 | 50* | | |
| A010 | Ship coal to EER (Progress Energy) | 09-26-05* | 10-12-05 | 10-18-05 | 15 | 0 | 15 | | |
| A020 | Test coal for sorbent viability | 10-13-05 | 11-16-05 | 11-22-05 | 30 | 0 | 30 | | |
| A030 | Submit test report | 11-17-05 | 11-22-05 | 11-28-05 | 5 | 0 | 5 | | |
| B001 | COMBUSTION OPTIMIZATION | 07-18-05 | 01-02-06 | 01-02-06 | 145* | 59 | 86* | 07-18-05 | |
| B010 | Order riffle boxes | 07-18-05 | 09-23-05 | 09-23-05 | 40 | 59 | 0 | 07-18-05 | 09-23-05 |
| B020 | Fabricate/deliver 3A riffle boxes | 09-02-05 | 09-23-05 | 09-23-05 | 20 | 19 | 0 | 09-02-05 | 09-23-05 |
| B021 | Fabricate/deliver 3B riffle boxes | 09-02-05 | 09-23-05 | 09-23-05 | 20 | 19 | 0 | 09-02-05 | 09-23-05 |
| B022 | Fabricate/deliver 3C riffle boxes | 09-02-05 | 09-23-05 | 09-23-05 | 20 | 19 | 0 | 09-02-05 | 09-23-05 |
| B023 | Fabricate/deliver 3E riffle boxes | 09-02-05 | 10-05-05 | 10-21-05 | 20 | 19 | 10 | 09-02-05 | |
| B024 | Fabricate/deliver 3D riffle boxes | 09-02-05 | 10-05-05 | 10-28-05 | 20 | 19 | 10 | 09-02-05 | |
| B030 | Install 3A riffle boxes (Progress Energy) | 09-24-05* | 09-29-05 | 09-29-05 | 5 | 0 | 5 | | |
| B031 | Install 3B riffle boxes (Progress Energy) | 10-01-05* | 10-06-05 | 10-06-05 | 5 | 0 | 5 | | |
| B032 | Install 3C riffle boxes (Progress Energy) | 10-15-05* | 10-20-05 | 10-20-05 | 5 | 0 | 5 | | |
| B033 | Install 3E riffle boxes (Progress Energy) | 10-22-05* | 10-27-05 | 10-27-05 | 5 | 0 | 5 | | |
| B034 | Install 3D riffle boxes (Progress Energy) | 10-29-05* | 11-09-05 | 11-09-05 | 10 | 0 | 10 | | |
| B040 | Boiler walkdown | 09-22-05 | 09-23-05 | 09-23-05 | 1 | 2 | 0 | 09-22-05 | 09-23-05 |
| B045 | Optimization test plan matrix | 09-26-05* | 10-06-05* | 10-06-05* | 10 | 0 | 10 | | |
| B050 | Optimization test plan - draft | 09-26-05* | 10-06-05 | 11-10-05 | 10 | 0 | 10 | | |
| B051 | Optimization test plan - PE review | 10-07-05 | 10-18-05 | 11-22-05 | 10 | 0 | 10 | | |
| B052 | Optimization test plan - final | 10-19-05 | 10-24-05 | 11-28-05 | 5 | 0 | 5 | | |
| B060 | Conduct boiler optimization testing | 11-29-05* | 12-21-05 | 12-21-05 | 20 | 0 | 20 | | |
| B070 | Submit boiler optimization test report | 12-22-05 | 01-02-06 | 01-02-06 | 10 | 0 | 10 | | |
| C001 | DUCT HUMIDIFICATION SYSTEM | 07-27-05 | 08-13-06 | 04-01-05 | 195* | 51 | 145* | 07-27-05 | |
| C010 | Prepare proposal for humid. system- BHA | 07-27-05 | 08-23-05 | 08-23-05 | 50 | 24 | 0 | 07-27-05 | 08-23-05 |
| C020 | Review proposal - EER | 09-26-05* | 10-06-05 | 10-26-05 | 10 | 0 | 10 | | |
| C030 | Issue purchase order to BHA | 10-07-05 | 10-18-05 | 11-07-05 | 10 | 0 | 10 | | |
| C035 | Humid. system - review mtg w/PE | 10-19-05 | 10-24-05 | 11-12-05 | 5 | 0 | 5 | | |
| C040 | Humid. system - design | 10-25-05* | 11-16-05 | 12-06-05 | 20 | 0 | 20 | | |
| C041 | Humid. system - EER review | 11-17-05 | 11-28-05 | 12-17-05 | 10 | 0 | 10 | | |
| C042 | Humid. system - PE review | 11-29-05 | 12-09-05 | 12-29-05 | 10 | 0 | 10 | | |
| C043 | Humid. system - final | 12-10-05 | 12-21-05 | 01-10-05 | 10 | 0 | 10 | | |
| C050 | Fabricate/deliver humid. system | 12-22-05 | 08-13-06 | 04-01-05 | 70 | 0 | 70 | | |
| D001 | ACTIVATED CARBON SYSTEM | 09-26-05 | 04-03-06 | 04-03-05 | 163* | 0 | 163* | | |
| D010 | AC system conceptual design | 09-26-05* | 10-18-05 | 11-07-05 | 20 | 0 | 20 | | |
| D020 | AC system comp. des. - review mtg w/PE | 10-19-05 | 10-24-05 | 11-12-05 | 5 | 0 | 5 | | |
| D030 | AC system detail - design-draft | 10-25-05 | 11-16-05 | 12-06-05 | 20 | 0 | 20 | | |
| D031 | AC system detail design - PE review | 11-17-05 | 11-28-05 | 12-17-05 | 10 | 0 | 10 | | |
| D032 | AC system detail design - final | 11-29-05 | 12-09-05 | 12-29-05 | 10 | 0 | 10 | | |
| D040 | Issue purchase order for injectors | 12-10-05 | 12-27-05 | 02-14-05 | 15 | 0 | 15 | | |
| D050 | Fabricate and deliver injectors | 12-28-05 | 08-11-06 | 04-01-05 | 40 | 0 | 40 | | |
| D060 | Issue purchase orders for AC system | 12-10-05 | 01-02-06 | 01-21-05 | 20 | 0 | 20 | | |
| D070 | Fabricate and deliver AC materials | 01-03-06 | 08-13-06 | 04-01-05 | 60 | 0 | 60 | | |
| D080 | All materials on site | 04-03-06* | 04-03-06 | 04-03-05 | 1 | 0 | 1 | | |
| E001 | INSTALLATION | 12-23-05 | 05-29-06 | 05-29-05 | 136* | 0 | 136* | | |
| E010 | Prepare installation package | 12-23-05 | 01-07-06 | 02-14-05 | 15 | 0 | 15 | | |

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| Finish date | 09-26-05 |
| Data date | 09-24-05 |
| Run date | 09-26-05 |
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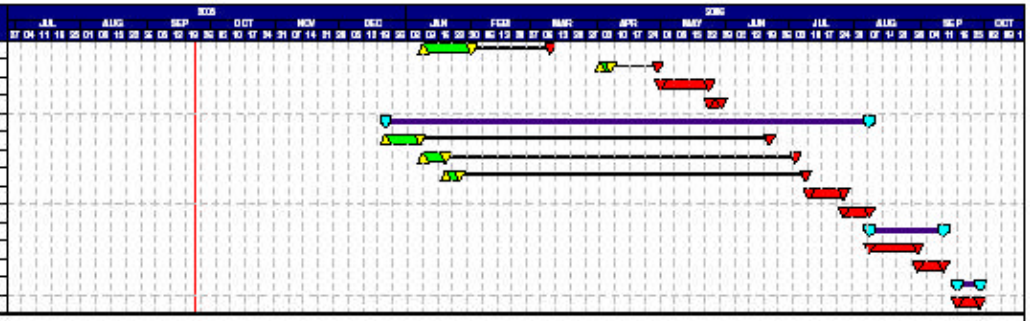
Progress Energy - Lee Station
Evaluation of Mercury Control

Early start point
Early finish point
Early bar
Late finish point
Total float bar
Progress bar
Critical bar
Summary bar
Progress point
Critical point
Summary point
Start milestone point
Finish milestone point

Table 1. Project schedule (cont.).

| Activity ID | Description | Early Start | Early Finish | Late Finish | Orig Dur | Act Dur | Rem Dur | Actual Start | Actual Finish |
|---|---|---|---|---|---|---|---|---|---|
| E020 | Issue purchase order for installation | 01-09-06 | 01-31-06 | 03-09-06 | 20 | 0 | 20 | | |
| E030 | Installation of injectors | 04-03-06* | 04-07-06 | 04-29-06 | 5 | 0 | 5 | | |
| E040 | Installation of remaining equipment | 05-01-06* | 05-23-06 | 05-23-06 | 20 | 0 | 20 | | |
| E050 | Final walkdown and sign off | 05-24-06 | 05-29-06 | 05-29-06 | 5 | 0 | 5 | | |
| F001 | OPTIM. OF MERCURY REMOVAL | 12-22-05 | 08-07-06 | 08-07-06 | 195* | 0 | 195* | | |
| F010 | Optimization test plan - draft | 12-22-05 | 01-07-06 | 06-21-06 | 15 | 0 | 15 | | |
| F011 | Optimization test plan - PE review | 01-09-06 | 01-19-06 | 07-03-06 | 10 | 0 | 10 | | |
| F012 | Optimization test plan - final | 01-20-06 | 01-25-06 | 07-08-06 | 5 | 0 | 5 | | |
| F020 | Conduct optimization testing | 07-10-06* | 07-26-06 | 07-26-06 | 15 | 0 | 15 | | |
| F030 | Submit test report | 07-27-06 | 08-07-06 | 08-07-06 | 10 | 0 | 10 | | |
| G001 | DEMON. OF MERCURY REMOVAL | 08-08-06 | 09-11-06 | 09-11-06 | 30* | 0 | 30* | | |
| G010 | Testing | 08-08-06 | 08-30-06 | 08-30-06 | 20 | 0 | 20 | | |
| G020 | Submit report | 08-31-06 | 09-11-06 | 09-11-06 | 10 | 0 | 10 | | |
| H001 | EQUIPMENT REMOVAL | 09-18-06 | 09-28-06 | 09-28-06 | 10* | 0 | 10* | | |
| H010 | Remove all equipment | 09-18-06* | 09-28-06 | 09-28-06 | 10 | 0 | 10 | | |

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| Run date | 09-26-05 |
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Progress Energy - Lee Station
Evaluation of Mercury Control

- Early start point
- Early finish point
- Early bar
- Late finish point
- Total float bar
- Progress bar
- Critical bar
- Summary bar
- Progress point
- Critical point
- Summary point
- Start milestone point
- Finish milestone point

## 3.0 Baseline Mercury Measurements

On June 9, 2005 Hg emissions were measured at the Lee Station unit 3 stack. A total of 3 Ontario Hydro measurements were performed at normal unit operation conditions by GE Management Services, Inc. At each sampling condition a sample of coal was taken from coal mills. These samples were analyzed for Hg and HCl content, and coal ultimate analysis was also performed.

Table 2 shows results of Hg emissions measurements. Mercury concentration in the flue gas was in the range from 3.11 µg/dscm to 3.63 µg/dscm with an average Hg concentration of 3.53 µg/dscm. Measurements also showed that about 80% of total Hg at the stack was present in the oxidized form. Since most particulate matter is removed in ESP, it is not surprisingly that very little Hg was associated with particulate matter.

Table 2. Results of sampling using Ontario Hydro method.

| **Test Run Number** | **1** | **2** | **3** | **Average** |
|---|---|---|---|---|
| Source Condition | Normal | Normal | Normal | |
| Date | 6/9/2005 | 6/9/2005 | 6/9/2005 | |
| Start Time | 11:50 | 14:35 | 16:55 | |
| End Time | 13:45 | 16:23 | 18:50 | |
| **Particle Bound Mercury Emissions** | | | | |
| net µg detected: | 0.047 | 0.100 | 0.084 | |
| µg/dscm: | 0.020 | 0.045 | 0.037 | 0.03 |
| lb/hr: | 0.000045 | 0.000096 | 0.000080 | 0.00 |
| **Oxidized ($Hg^{2+}$) Mercury Emissions** | | | | |
| net µg detected: | 6.7 | 6.9 | 5.5 | |
| µg/dscm: | 2.914 | 3.106 | 2.411 | 2.81 |
| lb/hr: | 0.0064 | 0.0066 | 0.0053 | 0.0061 |
| **Elemental ($Hg^{0}$) Mercury Emissions** | | | | |
| net µg detected: | 1.602 | 1.524 | 1.521 | |
| µg/dscm: | 0.697 | 0.686 | 0.667 | 0.68 |
| lb/hr: | 0.0015 | 0.0015 | 0.0015 | 0.0015 |
| **Total Mercury Emissions** | | | | |
| net µg detected: | 8.349 | 8.524 | 7.105 | |
| µg/dscm: | 3.631 | 3.837 | 3.115 | 3.53 |
| lb/hr: | 0.00801 | 0.00816 | 0.00678 | 0.00765 |

Table 3 shows fuel ultimate analysis as well as Cl and Hg content for each test. Ultimate coal analysis was performed by Commercial Testing & Engineering Co. Fuel samples were analyzed for chlorine and Hg continent by Consol Energy laboratory. Fuel analysis shows that the fuel fired in Lee Station unit 3 is a low sulfur coal with relatively high Cl content. High Cl

content in coal is consistent with the high fraction of oxidized Hg from the total Hg measured at the stack. Analysis also suggests significant variability in Hg in coal content.

Table 3. Fuel composition.

| Test No | Units | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| Ult. Analysis: | wt % | | | |
| C | | 70.71 | 68.07 | 70.33 |
| H | | 4.70 | 4.72 | 4.74 |
| N | | 1.37 | 1.36 | 1.37 |
| S | | 0.83 | 0.82 | 0.82 |
| Ash | | 9.54 | 10.01 | 9.84 |
| O | | 6.84 | 8.71 | 6.77 |
| H2O | | 6.01 | 6.31 | 6.13 |
| Wet HV | Btu/lb | 12549 | 12383 | 12429 |
| Dry Analysis | wt % | | | |
| C | | 75.23 | 72.65 | 74.92 |
| H | | 5.00 | 5.04 | 5.05 |
| N | | 1.46 | 1.45 | 1.46 |
| S | | 0.88 | 0.88 | 0.87 |
| Ash | | 10.15 | 10.68 | 10.48 |
| O | | 7.28 | 9.30 | 7.21 |
| Dry HV | Btu/lb | 13351 | 13217 | 13241 |
| Cl in coal | wt%dry | 1560 | 1600 | 1460 |
| Hg in coal | ppb dry | 70 | 56 | 80 |
| Hg in coal | ppb wet | 66 | 52 | 75 |

Table 4 compares the theoretical concentration of Hg in the flue gas (calculated based on coal composition, Hg content, and measured $O_2$ concentration at the stack) and measured Hg concentration. Table 4 shows that Hg reduction from coal at the stack varied from 28% to 56% with average Hg reduction of 43%. Average Hg emissions during testing were 2.9 lb/TBtu. Analysis of fly ash collected from ESP showed that average LOI during testing was 16.2%.

Table 4. Summary of mercury testing.

| Test No | Theoretical Hg (dry) µg/m$^3$ | Stack $O_2$, dry % | Mercury Concentration in Stack Gas | | | | | | Mercury Reduction, % |
|---|---|---|---|---|---|---|---|---|---|
| | | | $Hg_p$ µg/dm$^3$ | $Hg^0$ µg/dm$^3$ | $Hg^{+2}$ µg/dm$^3$ | Hg total µg/dm$^3$ | Hg total (@0%O2) µg/dm$^3$ | Hg total, lb/TBtu | |
| 1 | 6.513 | 5.00 | 0.020 | 0.697 | 2.914 | 3.631 | 4.766 | 2.91 | 44.25 |
| 2 | 5.407 | 5.00 | 0.045 | 0.686 | 3.106 | 3.837 | 5.036 | 3.07 | 29.03 |
| 3 | 7.232 | 5.50 | 0.037 | 0.667 | 2.411 | 3.115 | 4.220 | 2.58 | 56.92 |

## 4.0 Combustion Optimization activities

Combustion optimization is an important element of the GE EER strategy to enhance "naturally" occurring fly ash Hg capture. It is expected that combustion optimization will (1)

result in more uniform carbon in ash distribution between unit 3's two exhaust ducts and within each duct and (2) improve combustion process and reduce CO emissions allowing deeper staging of the combustion process (more air is diverted from the main combustion zone to OFA) than at current combustion conditions thus decreasing $NO_x$ emissions and improving fly ash reactivity towards Hg. Fly ash reactivity will be further improved by lowering ESP temperature using duct humidification system.

Combustion optimization will include balancing of coal flow through individual burners to eliminate zones of carbon-rich combustion. Relatively high LOI and significant variations in LOI as combustion conditions change suggest that burners are unbalanced and that boiler LOI and CO emissions are dominated by the worst performing burners, which have improper combustion stoichiometry. Non-uniformity of coal and air flows to burners also results in flue gas stratification. Previous experience suggests that in boilers with unbalanced combustion systems LOI can vary by 50-100% within cross section of the exhaust duct. Mercury oxidation and absorption on fly ash in such non-optimized systems is not as effective as in units with uniform LOI distribution.

Initial assessment of the unit 3 performance conducted by GE EER personnel during a site visit suggested an opportunity for burner balancing to improve combustion process. Among indications of combustion imbalance is side to side variation in excess $O_2$ measured by four $O_2$ sensors located in the exhaust duct. More effective performance of OFA system may also potentially be achieved by closing down the burner air registers to increase windbox pressures and divert more air to the OFA ports. GE EER is developing a test matrix for combustion optimization tests based on the results of this assessment. Combustion optimization activities are preliminarily scheduled for December 2005.

The first activity in the combustion optimization task will be to measure coal flow through individual burners using the Rotorprobe system. Then controls on riffle boxes leading to burners with significant deviations from average coal flow will be adjusted to provide more uniform coal flow. After initial adjustment coal flow through the burners will be measured again and additional riffle box adjustment will be made if necessary. This procedure will be repeated until coal flows though individual burners are within ±10% of each other.

## 5.0 Future Work

Activities during next reporting period (September 27 – December 26) will focus on unit combustion optimization. Figure 1 shows Unit 3 set up of mills and burners. Unit 3 is a wall-fired unit equipped with 20 burners and five mills. During reporting period adjustable riffle boxes were installed on mills A and B. Installation of remaining adjustable riffle boxes on mills C, D, and E will be completed by the end of November 2005. Unit 3 combustion system will be optimized during 3 week program in December 2005. It is expected that Hg CEMs will be on site during these activities to characterize effect of combustion optimization on Hg emissions. Other activities during next reporting period will include (1) development of preliminary designs for activated carbon injection and duct humidification systems, (2) reviewing these designs with Progress Energy and Lee Station personnel, (3) development of detail designs of sorbent injection and humidification systems, and (4) shipment of 5 tons of coal from Lee Station to the GE EER facility in Santa Ana, CA for pilot-scale testing in 300 kW Boiler Simulator Facility (BSF). The goal of these tests is to identify combustion conditions that yield maximum Hg removal efficiencies. The effect of ESP temperature on Hg emissions will be also characterized. Tests of activated carbon injection upstream of the ESP will be conducted to determine the effect of activated carbon injection rate on Hg emissions. Pilot-scale testing is expected to be conducted in February 2006. Results of pilot-scale testing will then be used to define optimum Unit 3 operating conditions.

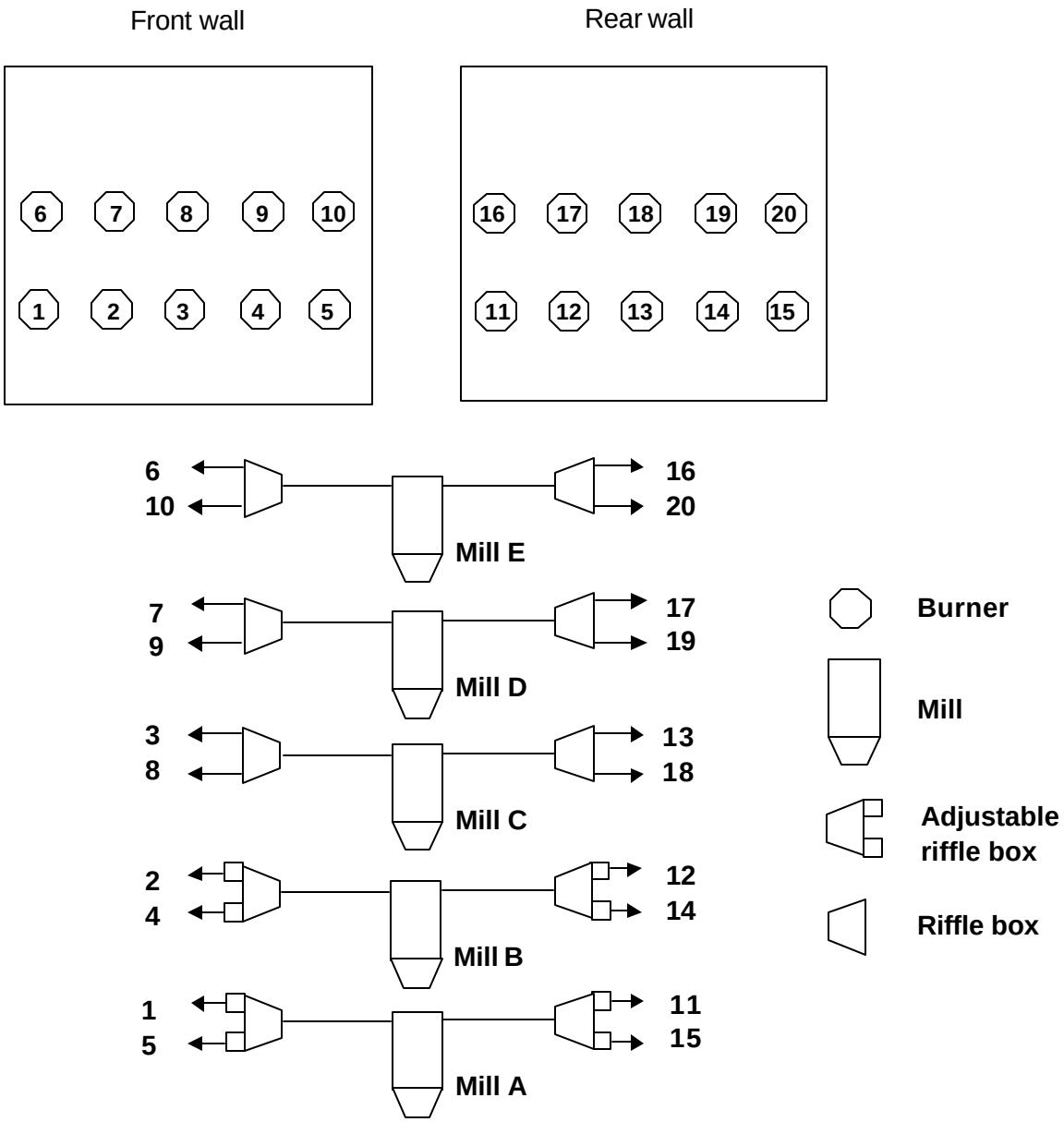


Figure 1. Unit 3 set up of mills and burners.

*Appendix A. Host Site Agreement*

Progress Energy

GE Energy & Environmental Research Corp.
(a wholly owned subsidiary of General Electric)
1831 E. Carnegie Ave.
Santa Ana, CA 92705

6-22-05

~~General Electric International, Inc.~~
~~421 Fayetteville Street Mall, Suite 1111~~
~~Raleigh, NC 27601~~

**Attention: Mr. Joseph Taura**

**CONTRACT NO. 10023**
**WORK AUTHORIZATION NO. 72**
**EFFECTIVE May 24, 2005**

**Under the terms of the above-referenced Contract, Progress Energy Service Company, LLC acting as agent for Progress Energy Carolinas, Inc., ("Owner") hereby offers the following work to your Company (hereinafter "Work").**

**Contractor is to develop a technology to control mercury emissions by integrating combustion optimization with duct humidification system and conduct a test of the technology on Unit No. 3 at Owner's H. F. Lee Plant located near Goldsboro, North Carolina in accordance with the detailed included in the attached Host Site Agreement Scope of Work.**

**Owner's Designated Representative for this Work is Mr. Peter Hoeflich-Lead Project Engineer.**

**Work shall begin on or about June 15, 2005 and shall be completed no later than December 31, 2006. The exact dates for performance of the Work shall be as directed by Owner's Designated Representative.**

**Owner will pay Contractor, as full compensation for the above Work the not-to-exceed amount of $100,000 as described in the attached document.**

**Invoices for Work performed under this Work Authorization shall be sent to Mr. Peter Hoeflich-Lead Project Engineer, c/o Progress Energy Carolinas, Inc., 410 South Wilmington Street, Raleigh, NC 27601. All invoices must reference Owner's Work Authorization Number and the name of the plant where the Work was performed.**

Progress Energy Service Company, LLC
P.O. Box 1551
Raleigh, NC 27602

Subject to the above conditions, final payment will be made not later than thirty (30) days after receipt of Contractor's invoice and all of the following have been completed:

A correct invoice covering the Work has been presented to Owner.

Contractor assumes exclusive liability for all sales or use taxes applicable to any materials, supplies, equipment or tools purchased, rented, leased, used or otherwise consumed by Contractor in conjunction with the performance of the Work.

Contractor shall invoice the sale of tangible personal property separately from the provision of labor or services. Tangible personal property includes, but is not limited to, (a) tools, equipment or other property used by Contractor in performance of the Work; and (b) materials, parts or other property that Contractor installs, incorporates, furnishes or otherwise supplies for Owner's use or consumption that becomes the property of Owner.

Contractor shall separately invoice Owner for property purchased by Owner as part of the Work, the price of installing the property, and the price of any training and/or testing associated with the Work. Invoices for tangible personal property sold to Owner shall contain a note stating, "Property Transferred to Owner."

As required by the Insurance Section of the Contract, before any Work is performed and before any invoices are paid for Work performed under this Work Authorization, written proof of compliance with the insurance requirements of the above-referenced Contract must be on file with Owner on a certificate executed by an authorized representative of Contractor's insurer and identified by the Owner Contract number.

If any conflicts exist between the provisions of this Work Authorization and the provisions of the Contract under which this Authorization is let, or any Amendment to this Contract, the provisions of this Work Authorization shall govern the Work described above. All other items in the Contract or Contract Amendments remain unaffected by this Work Authorization.

This Work Authorization and the Contract, as amended, embody the entire agreement between Owner and Contractor for the Work described above. The parties shall not be bound by or liable for any statement, writing, representation, promise, inducement or understanding not set forth within this document, itself. No changes, modifications, or amendments of any terms and conditions of this Work Authorization are valid or binding unless agreed to by both parties in writing and signed by their authorized agents.

- Next paragraph begins on the following page -

**Page 3, Work Authorization No. 10023-72**

**Please execute this Work Authorization, retain a copy for your file, and return the other original within ten (10) calendar days to Mr. James W. Pearce, P. E., Progress Energy Service Company, LLC, 410 South Wilmington Street (PEB 2C3), Raleigh, North Carolina 27601.**

**Sincerely,**

**James W. Pearce, P. E.**
**PROGRESS ENERGY SERVICE COMPANY, LLC**
***Not in its individual capacity, but solely as agent for***
**PROGRESS ENERGY CAROLINAS, INC.**

**Accepted:**

**GENERAL ELECTRIC INTERNATIONAL, INC.**

**By:** Blair A. Folsom

**Name (printed):** Blair A. Folsom

**Title:** Manager

**Date:** June 17, 2005

**Should the person's title who is executing this document not indicate that he/she is a corporate officer, an affidavit signed by a corporate officer shall be provided stating that the person whose name appears above is duly authorized to execute Contracts on behalf of the firm.**

_____

**(Contractor to fill in name and title)**
**is appointed as the person to whom all official correspondence to Contractor concerning this Work Authorization should be directed.**

## WORK AUTHORIZATION - HOST SITE AGREEMENT –SCOPE OF WORK

This Work Authorization shall serve as a Host Site Agreement ("Agreement") - Scope of Work between GE Energy and Environmental Research Corporation, a corporation under the laws of the State of California, USA, with its principal place of business in Irvine, CA, ("EER") and Progress Energy Carolinas, Inc. (Progress Energy) a company organized and existing under the laws of North Carolina, with its principal place of business in Raleigh, NC. Hereinafter EER and Progress Energy are referred to as the Parties (together) and separately as a Party. This Agreement shall become effective immediately upon execution of this Agreement by duly authorized representatives of the Parties (the "Effective Date").

This agreement is provided as an Attachment to and a part of Work Authorization No. 72, and subject to the terms and conditions of Contract XM80380000; Ref: 10023 between Carolina Power and Light Company and General Electric Company, as Amended for this Scope of Work.

**WITNESSETH**

WHEREAS EER is developing a technology to control mercury emissions by integrating combustion optimization with duct humidification system and activated carbon injection in combustion systems ("Technology"); and

WHEREAS EER desires to conduct a test of the Technology on a boiler equipped with overfire air system ("Test"); and

WHEREAS Unit 3 of the Lee Fossil Steam Plant ("Host Boiler") is equipped with an overfire air system; and

WHEREAS Progress Energy desires EER to conduct the Test on the Host Boiler; and

WHEREAS the U.S. Department of Energy (DOE) has agreed to provide co-funding for the Test, subject to certain project requirements;

WHEREAS a Contract exists between Carolina Power and Light Company and General Electric Company (#XM80380000; Ref# 10023);

NOW THEREFORE, In consideration of the mutual covenants herein contained, the Parties hereby agree as follows:

### 1.0 Technology Test on Host Boiler

The Parties agree to cooperate on a Test of the Technology on the Host Boiler during 2005 and 2006. Each party shall be responsible for all costs

associated with its own scope of work. Both parties understand that this Agreement is contingent upon execution of the referenced Contract between DOE and EER and agree that compliance with the Contract between the DOE and EER is precedent to this Work Authorization.

## 2.0 EER Scope of Work

EER agrees to do the following:

2.1 Program Manager; EER shall assign a Program Manager for the project who will coordinate communications between EER and Progress Energy.

2.2 Test Planning EER shall provide Progress Energy with a test plan (the "Test Plan") which describes the modifications and equipment to be supplied by EER and installed on the Host Boiler, as well as test conditions, measurement methods, personnel and schedule for the Test. The Test Plan will be a working document and will be developed, approved, and updated via mutual agreement of the Parties as the Test progresses. EER will review with Progress Energy the technical design of the in-duct humidification system prior to installation.

2.3 Installation EER shall procure and install all additional apparatus and equipment on and around the Test Boiler as provided in the Test Plan, except as noted in Progress Energy Scope of Work, to be used in conjunction with the Test. This equipment will include, but may not be limited to, adjustable riffle boxes or other mutually agreed upon functionally equivalent coal control device, additional temporary instrumentation and controls, temporarily installed hardware for the injection of mercury adsorption additives upstream of the existing electrostatic precipitator, and a temporarily installed in-duct humidification system upstream of the existing electrostatic precipitator. These systems are intended for use during the test program to demonstrate concept feasibility

2.4 Test Preparations EER shall provide and set up the measurement equipment for the Test including a continuous emissions monitoring system and mercury measurements as well as other instrumentation as required by the test plan.

2.5 Test EER shall direct the Test by specifying boiler operating conditions subject to section 3.4. EER shall operate the temporarily installed systems subject to section 3.4.

2.6 Data Collection EER personnel shall record control room data, and data from instrumentation provided by EER.

2.7 Cleanup Following the Test, EER shall remove all items supplied by EER and leave the Host Boiler in an "as found" condition, except as mutually agreed between Progress Energy and EER. Some equipment may be left in place, if desired by Progress Energy and mutually agreed, subject to DOE requirements.

2.8 Data Analysis and Report Following the Test, EER shall analyze the data and provide Progress Energy with a test report for Progress Energy internal use only.

2.9 DOE Coordination Project communication and co-ordination with DOE, to insure compliance with all DOE project requirements and obligations.

## 3.0 Progress Energy Scope of Work

Progress Energy agrees to do the following:

3.1 Test Planning Progress Energy shall review the Test Plan and in-duct humidification system design and provide comments to EER. Progress Energy and EER will review the Test Plan on a periodic basis and modify as appropriate to insure the goals of the Test are met while minimizing impact, if any, on the normal operation of the Test Boiler and auxiliary equipment.

3.2 Co-Funding: Progress Energy shall contribute co-funding in the amount of $200,000 consisting of both in-kind (personnel costs) and cash contributions. Upon signing of this agreement, and as a part of Progress Energy's co-funding obligation, Progress Energy shall issue a purchase order to EER in the amount not to exceed $100,000 for procurement and installation of adjustable riffle boxes or mutually agreed upon equivalent coalflow and airflow control hardware to be invoiced upon delivery of hardware. Progress Energy will provide support from their engineering and operational staffs

3.3 Test Preparations Progress Energy shall provide EER with access to the Host Boiler for installation of the EER provided equipment and instrumentation. Progress Energy will also supply connections for and use of utilities including electrical power, instrument air, and water, as required for the Test.

3.4 Test Operation of the Host Boiler is the responsibility of Progress Energy. Progress Energy shall provide EER with access to the Host Boiler during the Test. To the extent that planned test conditions do not adversely affect boiler operations or impose undue economic burden, Progress Energy shall operate the Host Boiler in accordance with the

Test Plan as updated by mutual agreement of the Parties. Progress Energy shall provide all fuels, utilities, maintenance and personnel necessary for operation of the boiler during the test.

3.5 DOE and EPA access. Progress Energy will provide access to DOE/NETL and EPA personnel to the Host Boiler at all times during the Test, subject to DOE/EPA's agreement to comply with all Plant rules and regulations applicable to visitors to the Host Boiler. These personnel will monitor and evaluate mercury sampling and QA/QC protocols during testing.

3.6 Data Collection Progress Energy shall provide EER with control room data and any other plant operating data during the tests. Any information supplied by Progress Energy that is considered to be confidential will be marked as confidential.

3.7 Cleanup Progress Energy shall provide EER with access to the Host Unit for cleanup. Progress Energy shall be responsible for cleanup of items supplied by Progress Energy.

3.8 Data Analysis and Report Progress Energy shall review the test report and provide comments to EER.

**4.0 Amendments to Contract**

The following Amendments to the Contract shall exclusively apply to this Work Authorization. All other provisions of the Contract and Work Authorization shall remain, and these Amendments are intended for this Work Authorization only, and shall not apply to other Work agreed to between the parties.

Section 12. WARRANTY AND INSPECTION OF MATERIALS

*As a clarification to this Article, the only materials supplied by Contractor that are covered by any warranty are the riffle boxes or other coal flow control device referenced in Article 2.3, to be permanently installed and any other new equipment. The warranty on these materials will be limited to the lesser of the Contract Warranty, Section 12,, or the standard warranty provided by the original equipment manufacture (OEM) of the devices.*

Section 33. CONFIDENTIALITY

Article 33. A.

*As a clarification, this Work (Test) will be co-funded by the US Department of Energy (DOE), through a separate Contract between the Contractor and the*

*DOE (to be shared with Progress Energy). To the extent required by this DOE contract, and subject to the Confidentiality provisions of the Contract, EER may provide information regarding this Work Authorization and Contract to the US DOE. Information provided will be limited to the extent required by the terms of the DOE/EER Contract.*

Article 33.C.

*Article 33.C. is deleted from the terms of this Work Authorization 72.*

Section 34. LIMITATIONS OF LIABILITY

Article 34.A.1

*For the purposes of this Article the Work Authorization Value is $100,000. The Limitation of Liability shall be the Work Authorization Value*

Article 36. INVENTIONS AND PROPIETARY RIGHTS

*Add the following Article 36.*

36.1 Nothing in this Agreement shall be construed as EER providing a license to Progress Energy of any rights to use the Technology except for Progress Energy's use of the Technology for the Test on the Host Boiler.

36.2 Progress Energy and EER shall mutually own data from the Test. All inventions and intellectual property related to the Technology and Test shall remain the property of EER. If required, both parties and any consultants retained by either party may be required to sign documentation as necessary to effect such ownership and patent procurement.

36.3 Parties understand that each Party may be engaged in ongoing research and development work. The Parties agree that such on-going research and development is outside the scope of this Agreement except inventions and other intellectual property related to the Technology of the Test, which EER shall own.